

CLAIMS

1. A method of generating a check matrix for a low-density parity-check code in which at least one of weights of a column and a row are not uniform, the method comprising:

5 determining a code length and a coding rate;

determining the weights of the row and the column to determine a basic matrix that satisfies conditions that "the weights of the row and the column are constant" and "number of cycles is equal to or more than six";

10 selecting a maximum value of the weight of the column that satisfies a condition of " $2 < \text{maximum value of the weight of the column} \leq \text{number of 1s within columns in the basic matrix}$ ";

searching provisionally an ensemble of the weights of the row and the column weights of the low-density parity-check code via
15 optimization based on Gaussian approximation in a state that number of the weights of the row are limited to continuous two kinds to determine an optimum set of the weights of the row;

deleting the rows sequentially from a bottom of the basic matrix considering number of rows after a division;

20 searching provisionally an ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row as a fixed parameter, to determine an optimum set of the weights of the column;

25 searching an optimal ensemble of the weights of the row and

the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row and the column as a fixed parameter; and

dividing at random the weights of the row and the column of the
 5 basic matrix after deleting the rows in a predetermined procedure based on a final ensemble.

2. A method of generating a check matrix for a low-density parity-check code in which at least one of weights of a column and a
 10 row are not uniform, using a Euclidean geometry code, the method comprising:

determining a code length and a coding rate;
 selecting the Euclidean geometry code that becomes a base;
 rearranging the Euclidean geometry code selected, based on a
 15 specific relational equation to create a basic matrix;
 selecting a maximum value of the weight of the column that satisfies a condition of " $2 < \text{maximum value of the weight of the column} \leq \text{number of 1s within columns in the Euclidean geometry code}$ ";
 searching provisionally an ensemble of the weights of the row
 20 and the column weights of the low-density parity-check code via optimization based on Gaussian approximation in a state that number of the weights of the row are limited to continuous two kinds to determine an optimum set of the weights of the row;
 deleting the rows sequentially from a bottom of the basic matrix
 25 considering number of rows after a division;

searching provisionally an ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row as a fixed parameter, to determine an optimum set of the weights of the column;

searching an optimal ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row and the column as a fixed parameter; and

dividing at random the weights of the row and the column of the basic matrix after deleting the rows in a predetermined procedure based on a final ensemble.

3. The method according to claim 2, wherein the specific relational equation used at the rearranging is generated such that the weights within the matrix are arranged at a higher position within columns.

4. The method according to claim 2, wherein in the Gaussian approximation, the optimal ensemble of the weights of the row and the column, which minimizes a threshold, is searched in a single linear programming such that a Gaussian noise becomes maximum in a state that the coding rate is fixed.

5. The method according to claim 2, wherein at the searching the optimum ensemble of the row and the

column of the low-density parity-check code, a weight distribution in the ensemble is adjusted such that a total number of the weights in weight unit is equal to an integer and a sum of the total number of the weights in the weight unit is equal to a total number of 1s in the Euclidean

5 geometry code, and

at the dividing, the dividing is performed based on the ensemble after an adjustment.

6. The method according to claim 2, wherein at the dividing, a

10 Latin square of basic random sequence is generated, and a weight of 1 is extracted from each of the rows and each of the columns in the basic matrix after deleting the row, thereby dividing each of the rows and each of the columns at random based on the Latin square.

15 7. A method of generating a check matrix for a low-density parity-check code in which at least one of weights of a column and a row are not uniform, using a Caylay graph, the method comprising:

determining a code length and a coding rate;

20 determining the weights of the row and the column in the Caylay graph, which becomes a base, to create a basic matrix;

selecting a maximum value of the weight of the column that satisfies a condition of " $2 < \text{maximum value of the weight of the column} \leq \text{number of 1s within columns in the Caylay graph}$ ";

25 searching provisionally an ensemble of the weights of the row and the column weights of the low-density parity-check code via

optimization based on Gaussian approximation in a state that number of the weights of the row are limited to continuous two kinds to determine an optimum set of the weights of the row;

deleting the rows sequentially from a bottom of the basic matrix
 5 considering number of rows after a division;

searching provisionally an ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row as a fixed parameter, to determine an optimum set of the weights of
 10 the column;

searching an optimal ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row and the column as a fixed parameter; and

15 dividing at random the weights of the row and the column of the basic matrix after deleting the rows in a predetermined procedure based on a final ensemble.

8. The method according to claim 7, wherein in the Gaussian
 20 approximation, the optimal ensemble of the weights of the row and the column, which minimizes a threshold, is searched in a single linear programming such that a Gaussian noise becomes maximum in a state that the coding rate is fixed.

25 9. The method according to claim 7, wherein

at the searching the optimum ensemble of the row and the column of the low-density parity-check code, a weight distribution in the ensemble is adjusted such that a total number of the weights in weight unit is equal to an integer and a sum of the total number of the weights in the weight unit is equal to a total number of 1s in the Euclidean geometry code, and

at the dividing, the dividing is performed based on the ensemble after an adjustment.

10. The method according to claim 7, wherein at the dividing, a Latin square of basic random sequence is generated, and a weight of 1 is extracted from each of the rows and each of the columns in the basic matrix after deleting the row, thereby dividing each of the rows and each of the columns at random based on the Latin square.

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11. An apparatus for generating a check matrix for a low-density parity-check code in which at least one of weights of a column and a row are not uniform, using a Euclidean geometry code, the apparatus comprising:

20 a code-length/coding-rate determining unit that determines a code length and a coding rate;

a Euclidean geometry code selecting unit that selects the Euclidean geometry code that becomes a base;

a rearranging unit that rearranges the Euclidean geometry code selected, based on a specific relational equation to create a basic

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matrix;

a maximum-weight selecting unit that selects a maximum value of the weight of the column that satisfies a condition of " $2 < \text{maximum value of the weight of the column} \leq \text{number of 1s within columns in the}$

5 Euclidean geometry code";

a first weight searching unit that searches provisionally an ensemble of the weights of the row and the column weights of the low-density parity-check code via optimization based on Gaussian approximation in a state that number of the weights of the row are

10 limited to continuous two kinds to determine an optimum set of the weights of the row;

a deleting unit that deletes the rows sequentially from a bottom of the basic matrix considering number of rows after a division;

a second searching unit that searches provisionally an
15 ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row as a fixed parameter, to determine an optimum set of the weights of the column;

a third searching unit that searches an optimal ensemble of the
20 weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the weights of the row and the column as a fixed parameter; and

a dividing unit that divides at random the weights of the row and the column of the basic matrix after deleting the rows in a

25 predetermined procedure based on a final ensemble.

12. An apparatus for generating a check matrix for a low-density parity-check code in which at least one of weights of a column and a row are not uniform, using a Caylay graph, the apparatus comprising:

5 a code-length/coding-rate determining unit that determines a code length and a coding rate;

a Caylay-graph determining unit that determines the weights of the row and the column in the Caylay graph, which becomes a base, to create a basic matrix;

10 a maximum-weight selecting unit that selects a maximum value of the weight of the column that satisfies a condition of " $2 < \text{maximum value of the weight of the column} \leq \text{number of 1s within columns in the Caylay graph}$ ";

15 a first weight searching unit that searches provisionally an ensemble of the weights of the row and the column weights of the low-density parity-check code via optimization based on Gaussian approximation in a state that number of the weights of the row are limited to continuous two kinds to determine an optimum set of the weights of the row;

20 a deleting unit that deletes the rows sequentially from a bottom of the basic matrix considering number of rows after a division;

a second searching unit that searches provisionally an ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation,
25 using the set of the weights of the row as a fixed parameter, to

determine an optimum set of the weights of the column;

a third searching unit that searches an optimal ensemble of the weights of the row and the column of the low-density parity-check code via optimization based on Gaussian approximation, using the set of the
5 weights of the row and the column as a fixed parameter; and

a dividing unit that divides at random the weights of the row and the column of the basic matrix after deleting the rows in a predetermined procedure based on a final ensemble.